PHYTOTOXICOLOGY SOIL SURVEY IN THE VICINITY OF THE HIGHLAND CREEK SEWAGE TREATMENT PLANT INCINERATOR: SCARBOROUGH - 1987

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BACKGROUND

Between October 30 and November 5, 1987, scientists from the Phytotoxicology Section, Air Resources Branch, conducted a soil survey of residential properties in the vicinity of the Highland Creek Sewage Treatment Plant (HCSTP) incinerator in Scarborough. The HCSTP incinerates municipal sewage sludge. In addition to complaints regarding odour and fly ash, emissions from the HCSTP are a potential source of inorganic (mostly heavy metals) and organic contamination. The organic contaminants of greatest concern are polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs).

Heavy metals and some organic contaminants are usually present in low concentrations in sewage sludge; however, some organics may actually be formed during the incineration process or in the exhaust gas plume.

The closest meteorological station to the HCSTP is located 4 km NW at Scarborough College. For the period 1974 to 1980 the wind originated from a W direction 55% of the time compared to only 25% for E winds. During the time of the year when the ground is not snow covered, the wind was from the W or SW as much as 70% of the time. Therefore, emissions from this source would disperse primarily to the NE. The HCSTP incinerator stack is 76 m in height. Based on stack height and topography, two plume dispersion models were developed by Air Resources Branch engineers. The first model employs a shoreline scenario and predicts a maximum ground level concentration (C max) of emissions from the HCSTP incinerator on a ring located 400 m from the stack. The second model, which predicts emission dispersion as if the Lake Ontario shoreline were not a factor, identifies the C max at 861 m from the stack. The calculated C max is derived from a mathematical modelling exercise and is used to predict the distance from the stack at which the 1 hour ground level concentration is maximized. As wind speed changes from the optimal determined during the C max calculations the ground level concentrations would also change and the actual point of

impingement would move closer or farther from the source relative to the wind direction. The area in which the point of impingement most frequently occurs would be the area of greatest long term deposition and therefore, also the area of greatest soil accumulation of any contaminants emitted from the HCSTP. The zone of most frequent point of impingement has not been calculated; however, based on the characteristics of the source and the prevailing wind velocity, the Air Resources Branch modellers estimate that the area of greatest long term deposition would occur between 600 and 1000 m NE of the HCSTP incinerator stack (Ref. 9). Using the calculations, significant deposition could also occur to the E and SE of the source; but this is inconsequential from a soil accumulation perspective because Lake Ontario lies in this direction.

The topsoil used to dress residential properties after construction is characteristically neutral to slightly alkaline (pH 7 to 8) with a relatively high clay and organic matter content. Most heavy metals and chlorinated organic compounds are held tenaciously by colloidal particles in soils of this nature. Therefore, contaminants from the HCSTP incinerator deposited on residential properties will not be readily leached but will tend to accumulate in the upper few centimeters of the surface soil.

SOIL SAMPLE SITES

The attached figure illustrates the approximate locations of the 13 soil sample sites established for the HCSTP incinerator survey. All the sample sites, except No. 2, were residential lawns. Five sites (No.'s 1 to 5) were near or between the predicted two C max locations and three sites (No's 2,4 and 5) lie within the estimated area of greatest long term deposition. Six additional sites ranged from 940 m to 2,830 m downwind (N and NE) of the incinerator. One control location (No. 13) was selected 4.7 km upwind (NW) of the source. At a meeting of the Centennial Community Recreation Association held on January 25, 1988, the soil survey was discussed and concerns were raised regarding the appropriateness of the control location. The

committee felt it was too close to Highway 401, other major roadways, and an historical landfill site. The control location was situated on the W side of Morningside Avenue south of Military Trail, slightly more than 1 km S of Highway 401. Previous Phytotoxicology surveys along this highway have shown that a distance of 1 km is well beyond the zone of particulate deposition associated with the high density of fast moving vehicles. In addition, Morningside Avenue has a traffic density which is similar to Lawrence Avenue East, which bisects the HCSTP incinerator survey area. Therefore, any contaminants associated with vehicle emissions should be present in the soil in similar concentrations at both the control and survey sample sites. The concern regarding the landfill site is unfounded, because the control site sample was collected from the landscaped front yard of an apartment tower; therefore, indigenous soil was not sampled. The two main objectives of a control site are that it be outside the zone of influence of the pollution source and that it be representative of the survey environment. It was concluded that the selected control location met both of these objectives.

Site No. 2 was the only sample location which was not a residential lawn. This site was a small clearing adjacent to the E side of the creek in the ravine area, approximately 700 m NE of the HCSTP incinerator stack. All sites were clear of overhead obstructions or adjacent landscaping which could impede deposition from the incinerator. The sampling sites were sequentially numbered such that they reflect an increasing distance from the source.

SAMPLING METHODOLOGY

Representative soil samples destined for inorganic analysis were collected in duplicate from each of the 13 sample locations. A sample consisted of 15 to 20 soil cores 2 cm in diameter by 5 cm deep. The soil samples were placed in labelled plastic bags and returned to the Phytotoxicology laboratory for processing. The samples were air dried, pulverized and passed through a 45 mesh screen into labelled glass bottles. The prepared samples were forwarded to the MOE Inorganic

Trace Contaminants laboratory where they were analyzed for 16 elements. These elements included magnesium (Mg), molybdenum (Mo), sodium (Na), antimony (Sb), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn), iron (Fe), arsenic (As), calcium (Ca), cadmium (Cd), chromium (Cr), mercury (Hg), selenium (Se) and vanadium (V).

An additional single soil sample was collected at each site for organic analysis. The sampling procedure for organic analysis was different than that used for inorganic analysis in that the sampling equipment was scrubbed laboratory-clean between each site to ensure that no cross-sample contamination occurred.

Some of the inorganic elements are naturally present in soil in relatively high concentrations (parts per million or higher). The inorganic elements do not have an affinity for the chromed surface of the sampling equipment, and so it is acceptable to simply wipe the equipment free of visible soil residue between samples to control cross-sample contamination. However, many of the organic contaminants are present in extremely minute concentrations (parts per billion, or parts per trillion) and may have a significant tendency to adhere to the sampling equipment. Therefore, the equipment must be completely cleaned between samples, as even a very small degree of cross-sample contamination may significantly alter the analytical results.

For the organic sampling component of this survey, the equipment was washed between samples with an alconox detergent solution until all visible soil particles were removed. This washing step was followed by a distilled water rinse to remove the detergent. This was followed by a rinse with 95% denatured alcohol to completely dry the equipment. As a final step to remove any residual trace organics which may have adhered to the chromed surface of the sampling corer, it was then rinsed with hexane.

To further minimize any possibility of cross-site contamination, all sample locations were assumed to be contaminated relative to their distance from the source; accordingly, the sites farthest from the

MCSTP were sampled first, followed by progressively closer locations. The soil samples were placed in labelled, wide-mouthed, amber-coloured glass jars which had been solvent rinsed in preparation for organic samples. The sample jar lid was foil-lined and secured with tape when sample collection was completed. All filled glass jars were placed in an insulated, light-tight cooler until delivery to the MOE Organic Trace Contaminants laboratory.

At the laboratory, each of the soil samples for organic analysis was divided in half; one sub-sample was analyzed for PCDDs and PCDFs and the other was analyzed for PCBs.

RESULTS OF ANALYSIS:

INORGANIC CONTAMINANTS

The results of the analysis for inorganic elements are summarized in Table 1. All results are expressed in parts per million (ppm), mean of duplicate samples. The table is arranged such that the sample sites are listed in order of increasing distance from the incinerator stack. The mean concentration for each element from the 12 survey sites is listed near the bottom of the table, followed by the concentration detected at site No. 13, the control location. The last row in Table 1 lists the Phytotoxicology Upper Limit of Normal (ULN) concentration for each element. The ULN does not imply toxicity; rather, it is a guideline to identify concentrations which exceed the natural urban background range in Ontario. Statistically, the ULN is the mean plus three standard deviations of all the background or control samples collected from urban locations which are not known to be contaminated by an industrial pollution source. Therefore, the ULN incorporates 99% of the variation inherent in control data. Levels which exceed the ULN provide a strong indication that the soil has accumulated contaminants from an extraneous pollution source. Upper Limits of Normal have not been established for Mg, Na and Ca as an insufficient number of control data have been collected to adequately define an ULN (Mg, Na) or because the background variation is too great (Ca).

None of the element concentrations at any of the 12 survey sites exceeded the ULN, nor were any significantly different from the respective control site concentrations. In addition, none of 16 elements displayed any evidence of a concentration gradient with distance or direction from the incinerator, proximity to the C max, relation to wind direction or the estimated area of maximum long term deposition. All of the levels were well within the range commonly encountered in an urban environment. In fact, concentrations of some of the elements, specifically Pb, Zn and Cd, were quite low and were more characteristic of rural, rather than urban soil.

RESULTS OF PCDD AND PCDF ANALYSIS

The term dioxin refers to a family of 75 related chemical compounds known as polychlorinated dibenzo-p-dioxins (PCDDs). The 75 separate isomers of PCDD differ only by the number and position of the chlorine atoms attached to the two benzene rings of the PCDD molecule. In this study, isomer-specific identification was not attempted; rather, total concentrations of five congener groups of PCDD were obtained. The PCDD congener groups were tetraCDD (T_4CDD, i.e., a group of PCDDs which contain 4 chlorine atoms), pentaCDD (P_5CDD, containing 5 chlorine atoms), hexaCDD (H_6CDD, 6 chlorine atoms), heptaCDD (H_7CDD, 7 chlorine atoms) and octaCDD (O_8CDD, a PCDD group containing 8 chlorine atoms).

When the term dioxin is used, particularly in the popular media, it usually refers to the most toxic isomer of T_4CDD, which is 2,3,7,8-TCDD. Other PCDD isomers within the five major congener groups are less toxic than 2,3,7,8-TCDD by factors ranging up to thousands. The data in this report for the T_4CDD congener group may include the 2,3,7,8-TCDD isomer.

The term furan refers to a family of 135 related chemical compounds known as polychlorinated dibenzofurans (PCDFs). As with PCDDs, the various PCDF isomers differ in the number and position of the chlorine atoms. Isomer-specific PCDF analysis was not conducted with this study. Again, as with PCDD, the total concentrations of five PCDF congener

groups were determined. These congener groups were T_4CDF, P_5CDF, H_6CDF, H_7CDF and O_8CDF.

Dioxins and furans are not intentionally made for any purpose. They are compounds which can be created during the manufacture of other chemicals, such as some pesticides, plasticisers, di-electric fluids, wood preservatives and other chlorophenol products. Also, PCDDs and PCDFs may be formed as a result of incomplete combustion of mixtures containing chlorine and organic compounds. The extensive historical manufacture, use and disposal of products which potentially contain PCDDs and PCDFs or their precursors, particularly in the urban environment, has resulted in virtually ubiquitous contamination, although at extremely low concentrations. In Ontario, PCDDs and PCDFs have been detected in some samples of surface water (although not in treated drinking water), fish, soil, human adipose tissue, some sewage treatment plant sludes, and some food products.

Table 2 summarizes the results of the PCDD analysis of soil samples collected for the HCSTP incinerator survey. Dioxins from one or more of the five congener groups were detected in soil at 11 of the 13 sample sites, including the control location. The highest chlorinated O_8CDD was the most frequently encountered of the five congener groups, and it occurred in the highest concentration. For example, O_8CDD was detected in soil at 11 of the 13 sites in concentrations ranging from 120 to 1,500 parts per trillion (ppt). The congener group with the next highest concentration was P_5CDD, which was detected in soil at four of the 13 sites at concentrations ranging from 41 to 540 ppt. Soil at three of the sample sites contained T_4CDD, whereas both H_6CDD and H_7CDD were detected at two sites. The highest concentration of T_4CDD, which may or may not have included 2,3,7,8-TCDD, was 430 ppt detected at site No. 7. Site No. 7, located 1,360m NNW of the incinerator, also had the highest total PCDD concentration (2,770 ppt). This site is well beyond the C max and upwind of the source. There was no concentration gradient either with distance or direction relative to the incinerator. In fact, four of the five sites which were located on or between the two C max zones had four of the five lowest total PCDD

concentrations. Also, the three sites which were located within the estimated area of greatest long term deposition contained the three lowest total dioxin concentrations of the 10 survey area sites at which dioxins were detected. In addition, soil from these three sample sites contained no detectable T_4CDD. The closest site, No. 1, which was located 420 m NW near the calculated shore C max, contained no detectable PCDDs in the soil.

Ontario does not have a PCDD soil guideline. The only soil guideline available for reference is 1 part per billion (ppb). It was developed by the US EPA and applies only to 2,3,7,8-T_4CDD in residential soils. One ppb equals 1,000 ppt. By comparison the highest total T_4CDD concentration detected in the HCSTP incinerator survey was 430 ppt (0.43 ppb), which is less than half of the EPA guideline, even if all of the T_4CDD detected in this sample was the most toxic 2,3,7,8-T_4CDD isomer. At the national level in Canada, the Multimedia Guidelines Advisory Committee, which reports to the Canadian Council of Environment Ministers, has recommended a soil guideline of 1 ppb 2,3,7,8-TCDD toxic equivalents (TEQ) (Ref. 4). A TEQ is a mathematical function which converts concentrations of various PCDD and PCDF congeners groups, weighted by their relative toxicites, into an equivalent concentration of 2,3,7,8-TCDD. The following table illustrates that the survey sites with the two highest PCDD/PCDF concentrations both fall below the guideline whether they are calculated as TEQ or remain as absolute concentrations.

Site No.	T_4CDD (ppb)	Total PCDD + PCDF (ppb)	Calculated TEQ (ppb)
3	0.31	1.29	0.50
7	0.43	2.95	0.71
US EPA*	1.0		
Canadian Recommendation			1.0

* for 2,3,7,8-TCDD

The limits of analytical detection achieved for these trace organic compounds in soil are remarkably low. To place these small amounts into perspective it is often useful to relate the concentrations to a more readily recognizable equivalent. For example, one ppm (part per million) is mathematically equivalent to 1 inch in about 16 miles. One ppb (part per billion) is equivalent to 1 inch in about 16,000 miles. By comparison, one ppt, (part per trillion) the concentration used to describe the amount of PCDD and PCDF in soil in this survey, is equivalent to 1 inch in about 16 million miles.

Table 3 summarizes the PCDF results. Only O_8CDF was detected, and only at three of the 13 soil sample sites. The maximum PCDF concentration was 230 ppt, which was detected at site No. 3, 810 m NNW of the HCSTP incinerator stack. This site is situated on the C max ring. However, site No. 4 is also situated on the C max and is directly downwind in the estimated area of greatest long term deposition, and yet a lower PCDF concentration occurred at this location. Soil at other sample sites also on or near the C max, closer to the source, in the zone of greatest deposition, and farther from the source, contained no detectable PCDFs.

Samples of treated sewage sludge at the HCSTP have been collected in conjunction with other MOE studies (Ref. 10). Table 4 summarizes the range of PCDDs and PCDFs detected in treated sewage from the HCSTP.

Concentrations of T_4CDD were comparable to the soil levels but the O_8CDD levels were many times higher than the highest O_8CDD concentration detected in soil during the HCSTP soil survey. Additional sampling (Ref. 6) has not detected PCDDs or PCDFs in the bottom ash, effluent or stack gasses from the HCSTP incinerator. These data imply that the PCDDs and PCDFs entering the incinerator plant in the feed material (sewage sludge) are completely destroyed in the incineration process. However, this may not be the case, for although the bottom ash and effluent have been satisfactorily sampled, the stack gas sampling was not performed under isokinetic conditions. "Isokinetic conditions" require that the stack gas must be drawn into the sampling mechanism at the same velocity as the gas is moving in the stack. Isokinetic conditions ensure that the sample obtained is truely representative of the gas in the emission stream. This is particularly critical when sampling for organic compounds because it is believed that they are carried on fly ash and other particles. Isokinetic sampling conditions are difficult to obtain at the HCSTP incinerator because the facility is currently operating at approximately 1/3 of its design capacity. Therefore, it is possible that the non-detectable PCDD and PCDF results obtained with the stack gas sampling program may be inaccurate and that trace amounts of these compounds are being emitted. However, the data from the soil survey indicate that regardless of the possibility of the presence of PCDDs and PCDFs in emissions from the HCSTP incinerator, there is no evidence to suggest that the low level presence of these compounds in the soil is related to incinerator emissions.

SOIL DIOXIN LEVELS IN ONTARIO AND ELSEWHERE

Table 5 was prepared to place the urban soil data from the HCSTP incinerator survey into context relative to PCDD soil concentrations for comparable urban or industrial sites reported in the literature. Very few PCDF concentrations were reported in these literature references; therefore, furans were not included in this summary table. Table 5 is broken into three components: 1) soil concentrations associated with the manufacture and/or industrial use of chemicals

containing PCDDs; 2) soil levels detected in the vicinity of industrial accidents, spills, storage or test use of PCDD-containing chemicals; and 3) urban residential soil PCDD concentrations from the vicinity of municipal refuse incinerators, other industrial or combustion sources and the HCSTP sewage sludge incinerator. The data in Table 5 illustrate three significant points. The first is that the soil PCDD concentrations detected around the HCSTP incinerator are comparable to, in fact for all but the T_4CDDs, somewhat lower than those encountered in the vicinity of most municipal refuse incinerators. The T_4CDD levels were higher at three of the HCSTP incinerator sites. These T_4CDD concentrations may be related to the historical use of organo-chlorine herbicides, wood preservatives, the disposal of wood ash or the use of other soil amendments containing trace quantities of T_4CDD. The second point is that soil PCDD concentrations reported in the vicinity of municipal incinerators are orders of magnitude lower than those associated with the industrial use, manufacture or spills of chemicals containing PCDDs. The third point is that in cases where all 5 congener groups have been analyzed, both the frequency of detection and the concentration generally tend to increase with the degree of PCDD chlorination, i.e. $T_4CDD < P_5CDD < H_6CDD < H_7CDD < O_8CDD$.

In 1987, the Phytotoxicology Section conducted a soil background survey throughout Ontario for trace organic compounds, including PCDDs and PCDFs. Most of the sample sites were rural woodlots or wooded municipal parks remote from any known emission sources. The data from the background survey are summarized in Table 6. Also, listed in Table 6 are background data collected from several remote US locations. No T_4CDD, P_5CDD or H_6CDD were detected in the rural soils, whereas like other urban survey areas, they were present at some of the HCSTP soil survey sites. The H_7CDD concentrations were marginally lower and the O_8CDD levels were marginally higher in soil from the background survey relative to the results obtained in the vicinity of the HCSTP. The chlorination concentration gradient, that is the tendency towards increasing frequency of detection and concentration with increasing

degree of chlorination of the five congener groups, was consistent in both the background and the HCSTP surveys.

All five of the PCDF congener groups occurred in at least some of the background soil sites, whereas only O_8CDF was detected in soil in the vicinity of the HCSTP. The O_8CDF soil concentrations from the rural sites were only marginally lower than the HCSTP levels.

Table 7 compares the PCDD and PCDF soil analyses on the basis of frequency of occurrence. Data in this table include the results from the HCSTP Incinerator, the background survey, and the SWARU survey. SWARU is a large municipal refuse incinerator in Hamilton which has been in operation for 15 years. The Phytotoxicology Section conducted a soil PCDD and PCDF survey around this incinerator in 1983 using similar sampling and analytical methodology that was employed in the HCSTP survey. These frequency of occurrence data show that lesser chlorinated dioxins are slightly more prevalent in the HCSTP survey, whereas lesser chlorinated furans are less prevalent, in fact absent.

RESULTS OF PCB ANALYSIS

The PCB analysis was conducted to an analytical detection limit of 0.02 parts per million (ppm). The MOE has a PCB landfill guideline of 50 ppm; that is, soil containing greater than 50 ppm PCB cannot be disposed of in a municipal landfill. The Canadian Council of Environment Ministers adopted a series of interim national guidelines in September 1987 for PCB in residential soil. These guidelines are:

0.5 ppm - agricultural soil, including home gardens
5 ppm - non-agricultural soil, eg. residential or general public access.

No PCBs were detected in the soil samples collected in the HCSTP incinerator soil survey, i.e., PCB concentrations in all soil samples were less than 0.02 ppm. It is likely that PCBs would have been

detected if the analytical resolution were increased to ppb or ppt; however, in light of the existing and proposed guidelines, PCB quantification to the ppm level is acceptable. Previous Phytotoxicology Section surveys have determined that approximately 20% of urban residential properties in areas with no history of PCB manufacture or use have soil PCB concentrations ranging from 0.02 to 0.35 ppm (Ref. 8). Similarly, PCBs have been detected in soil from residential properties in small urban and rural centres and from some agricultural soil, although less frequently and generally in lower concentrations than in major urban areas.

CONCLUSIONS

On the basis of a soil survey conducted in 1987 by the Phytotoxicology Section on residential properties in the vicinity of the Highland Creek Sewage Treatment Plant incinerator, Scarborough, and comparison of the analytical results with other studies in Ontario and with the world literature, it can be concluded that:

1) None of the 16 inorganic elements exceeded existing guidelines nor was there any evidence of a concentration gradient with distance or direction from the incinerator or the estimated area of maximum long term deposition.

2) PCDDs and PCDFs are ubiquitous contaminants that occur in trace concentrations in urban residential and rural soils. PCDDs and PCDFs were detected in soil at concentrations comparable to those detected in the vicinity of other municipal refuse incinerators in Ontario and elsewhere although the T_4CDD levels at two of the 13 HCSTP sites were somewhat elevated. There was no evidence of a concentration gradient with distance or direction from the incinerator or relative to the estimated area of maximum long term deposition. The maximum T_4CDD concentration was less than half of the U.S. EPA guideline, assuming all the T_4CDD in the sample was the most toxic 2,3,7,8-TCDD isomer. The two samples with the

highest T_4CDD concentrations also were below the recommended Canadian residential soil guideline using the TEQ factor method.

3) PCBs were not detected in soil at any of the survey collection sites.

These data indicate that emissions from the HCSTP incinerator have had no measurable impact on the soil of residential properties in the area. However, in view of the elevated levels of T_4CDD at two of the upwind sites, additional sampling will be conducted in 1989 to further explore and confirm these findings.

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Table 1: Results of Inorganic Analysis of Soil Samples collected in the vicinity of the Highland Creek Sewage Treatment Plant Incinerator, Scarborough - 1987.

Site	Concentration: ppm, 0-5 cm, Dry Weight, Mean of Duplicate Samples															
	Mg	Mo	Na	Sb	Cu	Ni	Pb	Zn	Fe	As	Ca	Cd	Cr	Hg	Se	V
1 420 m NW	3,150	<1	215	0.36	14	8.2	32	49	14,500	2.9	10,300	0.4	20	0.03	0.40	32
2 700 m NE	5,400	<1	225	<0.30	6	4.7	10	22	8,750	1.1	49,000	<0.2	14	0.01	<0.30	20
3 810 m NNW	4,700	<1	220	<0.30	14	8.3	31	38	13,000	2.7	39,000	0.4	22	0.06	<0.30	28
4 940 m NE	4,350	<1	220	1.60	11	11.0	20	41	16,000	2.7	23,500	0.3	24	0.05	0.46	34
5 940 m NNE	3,500	<1	195	NA	13	13.0	19	50	18,500	NA	11,000	<0.2	21	NA	NA	36
6 1,210 m NNE	5,700	<1	245	<0.30	16	9.8	40	42	13,500	3.3	58,500	0.6	32	0.03	<0.30	26
7 1,360 m NNW	3,150	<1	170	<0.30	21	9.9	49	75	12,500	4.5	45,000	0.8	28	0.05	<0.30	23
8 1,430 m NE	4,450	<1	245	<0.30	17	10.0	33	53	14,000	2.0	30,500	1.0	43	0.04	0.55	31
9 1,690 m NNE	3,150	<1	220	0.34	9	8.9	22	39	14,000	2.6	9,200	0.4	22	0.03	0.44	30
10 2,160 m N	2,550	<1	170	<0.30	6	4.5	14	27	11,000	3.3	27,000	<0.2	14	0.01	0.31	24
11 2,380 m NE	5,300	<1	290	<0.30	19	13.0	92	80	15,500	3.1	33,000	0.6	26	0.04	0.66	32
12 2,830 m NE	3,150	<1	185	<0.30	7	6.8	15	38	16,500	5.9	26,000	<0.2	20	0.02	<0.30	32
13 4,700 m NW	3,900	<1	185	<0.30	12	7.4	74	62	12,500	2.2	27,000	0.3	19	0.02	0.50	27
U.L.N.	NE	3	NE	8	100	60	500	500	35,000	20	NE	4	50	0.5	2	70

NA not analysed
NE not established
U.L.N. upper limit of normal, described in text

DM/RE2849-TAB

Table 2: **Results of PCDD Analysis of Soil Samples Collected in the Vicinity of the Highland Creek Sewage Treatment Plant Incinerator, Scarborough - 1987.**

Soil* Site No.	Distance and Direction from Incinerator Stack	PCDD Congener Concentration (ppt)**					
		T_4CDD	P_5CDD	H_6CDD	H_7CDD	O_8CDD	Total
1	420 m NW	-	-	-	-	-	-
2	700 m NE	-	-	-	-	280	280
3	810 m NNW	310	370	-	-	380	1,060
4	940 m NE	-	-	70	-	180	250
5	940 m NNE	-	-	-	-	120	120
6	1,210 m NNE	-	-	-	-	1,200	1,200
7	1,360 m NNW	430	540	-	300	1,500	2,770
8	1,430 m NE	93	56	40	210	1,300	1,699
9	1,690 m NNE	-	-	-	-	-	-
10	2,160 m N	-	-	-	-	730	730
11	2,380 m NE	-	-	-	-	310	310
12	2,830 m NE	-	-	-	-	840	840
13	4,700 m NW (CONTROL)	-	41	-	-	220	261
Analytical detection limit		0.3	1.3	1.3	1.3	1.3	

* surface soil (sodded), 0-5 cm depth

** parts per trillion, dry weight (corrected for spike recovery)

\- absent data infers concentrations below analytical detection limit

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Table 3: Results of PCDF Analysis of Soil Samples Collected in the Vicinity of the Highland Creek Sewage Treatment Plant Incinerator, Scarborough - 1987.

Soil* Site No.	Distance and Direction from HCSTP Stack	PCDF Congener Concentration (ppt)**					
		T_4CDF	P_5CDF	H_6CDF	H_7CDF	O_8CDF	Total
1	420 m NW	-	-	-	-	-	-
2	700 m NE	-	-	-	-	-	-
3	810 m NNW	-	-	-	-	230	230
4	940 m NE	-	-	-	-	100	100
5	940 m NNE	-	-	-	-	-	-
6	1,210 m NNE	-	-	-	-	-	-
7	1,360 m NNW	-	-	-	-	180	180
8	1,430 m NE	-	-	-	-	-	-
9	1,690 m NNE	-	-	-	-	-	-
10	2,160 m N	-	-	-	-	-	-
11	2,380 m NE	-	-	-	-	-	-
12	2,830 m NE	-	-	-	-	-	-
13	4,700 m NW (CONTROL)	-	-	-	-	-	-
Analytical detection limit		0.3	1.3	1.3	1.3	0.8	

* surface soil (sodded), 0-5 cm depth

** parts per trillion, dry weight (corrected for spike recovery)

\- absent data infers concentrations below analytical detection limit

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Table 4: Range of PCDD and PCDF Detected*
In the HCSTP Treated Sewage Sludge.

Congener Group		Concentration Range, ppt
T_4CDD		ND - 63
P_5CDD		ND
H_6CDD	Dioxins	1,000 - 3,500
H_7CDD		13,000 - 33,000
O_8CDD		65,000 - 80,000
T_4CDF		ND
P_5CDF		ND
H_6CDF	Furans	ND - 320
H_7CDF		ND
O_8CDF		ND - 920

* data from the Municipal STP Toxics Survey Study and from sewage samples collected at the same time as the HCSTP soil survey.

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Table 5: Comparison of Literature Reported Ranges in Detectable PCDD Concentrations in Urban Soil

Source Type and Location	Range* (L) (H)	PCDD Congener Concentrations (ppt) T_4CDD	P_5CDD	H_6CDD	H_7CDD	O_8CDD	Reference
Industrial/Chemical Manufacturing Sites:							
Chlorophenol chemicals	L	1,100	ND	7,000	70,000	490,000	5
Midland, Michigan	H	118,000	ND	280,000	3,200,000	20,500,000	
Wood Preservative	L	ND	ND	100,000	1,000,000	16,000	2
New Castle, New Brunswick	H	ND	ND	100,000		1,500,000	
Wood Preservative	L	ND	ND	10,000	100,000	10	2
Truro, Nova Scotia	H	ND	ND	10,000	100,000	567,000	
Spills and Chemical Storage/Test Sites:							
Herbicide Test Site	L	10	NA	NA	NA	NA	12
Elgin A.F.B., Florida	H	1,500					
Herbicide Storage/Spill	L	21,000	NA	NA	NA	NA	12
Gulfport, Mississippi	H	340,000					
Industrial Accident	L	150	NA	NA	NA	NA	11
Seveso, Italy	H	55,000					
Urban Residential in Vicinity of Incinerators and other Industrial or Combustion Facilities:							
Municipal Incinerator	L	5	ND	20	100	350	5
Chicago, Illinois	H	30	ND	310	3,300	22,000	
Municipal Incinerator	L	2	9	1	6	6	3
Florence, Italy	H	3	51	57	97	230	
Municipal Incinerator	L	7	580	170	5	50	7
Hamilton, Ontario	H	7	580	170	390	3,500	
Chlorophenol Manufacturer	L	3	100	63	150	330	
Midland, Michigan	H	360	120	410	2,400	12,000	1
Steel Manufacturer	L	3	ND	ND	23	170	
Middletown, Ohio	H	5	ND	72	200	10,600	1
HCSTP Sewage Incinerator	L	93	4	40	210	120	
Scarborough, Ontario	H	430	540	70	300	1,500	

* L = Lowest Detected Level H = Highest Detected Level
ND PCDDs not detected (below reported detection limit)
NA analysis not conducted for these congener groups.
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Table 6: Range of Detectable PCDD and PCDF Concentrations in Soil* From Rural Woodlots and Urban Wooded Parks in Ontario - 1987, and Minnesota USA Natural Areas.

Congener Group		PCDD and PCDF Concentration (ppt) Range Minnesota**	Ontario
T_4CDD		ND	ND
P_5CDD		ND	ND
H_6CDD	Dioxins	ND	ND
H_7CDD		25-91	7 - 140
O_8CDD		130-200	40 - 11,000
T_4CDF		ND	37 - 64
P_5CDF		ND	10
H_6CDF	Furans	ND	11 - 35
H_7CDF		ND	36 - 60
O_8CDF		ND	50 - 160

* top 5 cm of mineral soil below the litter layer

** Reference 1

ND Congener group not detected in any samples

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Table 7: Comparison of the Concentration Range and Frequency of Occurrence for PCDD and PCDF Congeners of the HCSTP, SWARU and Rural/Urban Background Soil (RUBS) Surveys, Ontario

Congener Group	Analytical Detection Limit (ppt)	Concentration Range (ppt)			Frequency of Occurrence*		
		HCSTP	SWARU	RUBS	HCSTP	SWARU	RUBS
T_4CDD	0.3	ND-430	ND-7	ND	25%	9%	0%
P_5CDD	1.3	ND-540	ND-580	ND	33%	9%	0%
H_6CDD	1.3	ND-70	ND-170	ND	17%	9%	0%
H_7CDD	1.3	ND-300	ND-390	ND-140	17%	55%	41%
O_8CDD	1.3	ND-1500	ND-3500	ND-11000	83%	91%	59%
T_4CDF	0.3	ND	ND-71	ND-64	0%	18%	5%
P_5CDF	1.3	ND	ND	ND-10	0%	0%	8%
H_6CDF	1.3	ND	ND	ND-35	0%	0%	25%
H_7CDF	1.3	ND	ND-180	ND-60	0%	18%	17%
O_8CDF	0.8	ND-230	ND-33	ND-160	25%	27%	17%

* % of all survey sample sites sites where a measurable concentration of each congener group was detected.

HCSTP - Highland Creek Sewage Treatment Plant Incinerator, Scarborough, 1987

SWARU - Solid Waste Reduction Unit, municipal refuse incinerator, Hamilton,

RUBS - Rural/Urban Background Survey, 1987

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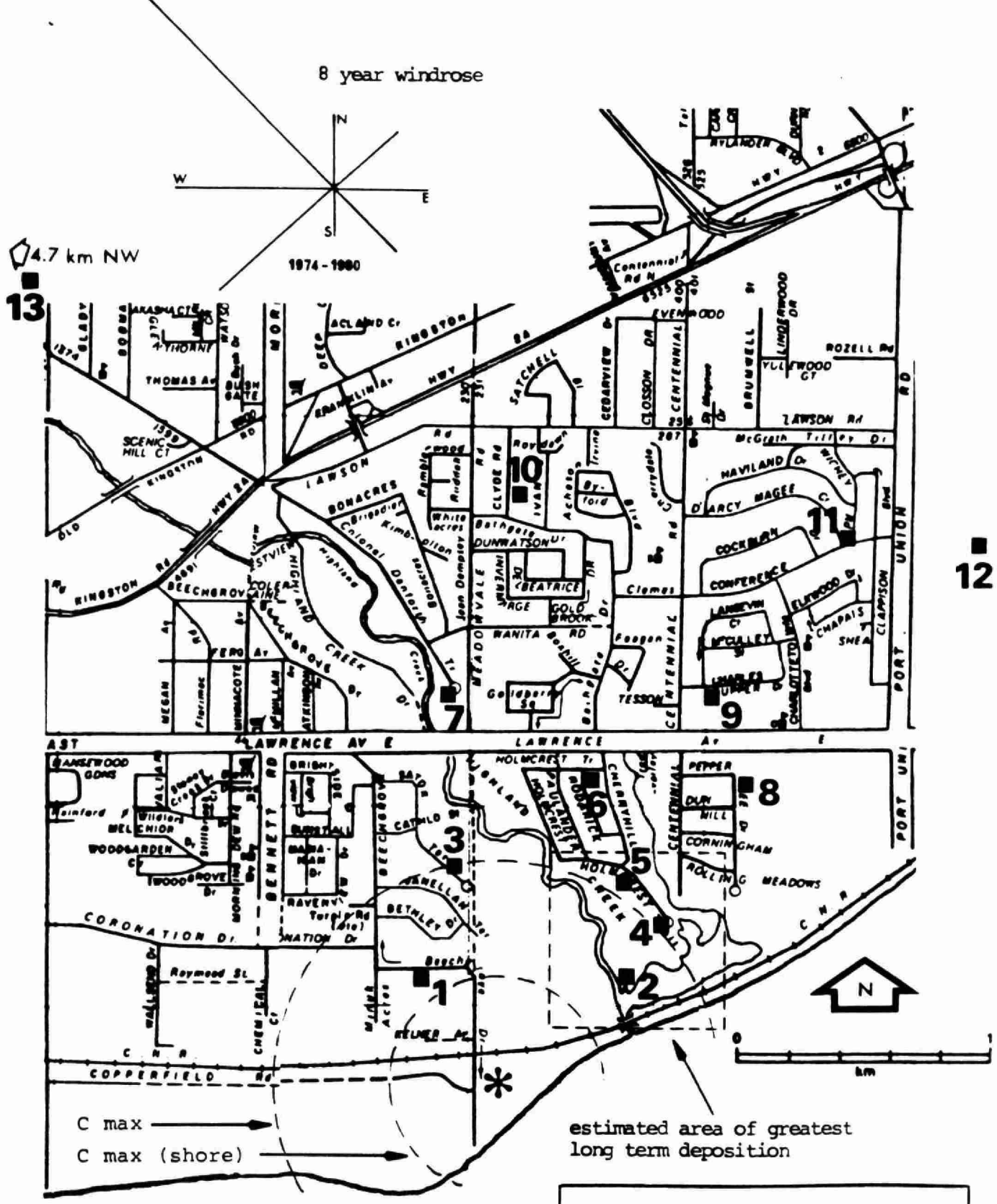

Location of Soil Sample Sites for the Highland Creek Sewage Treatment Plant Incinerator Soil Survey. October 1987.